SLOVENSKI STANDARD

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Neogrevane tlaļne posode - 4. del: Proizvodnja

Unfired pressure vessels - Part 4: Fabrication

Unbefeuerte Druckbehälter - Teil 4: Herstellung

Récipients sous pression non soumis a la flamme - Partie 4: Fabrication

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Unfired pressure vessels - Part 4: Fabrication

Récipients sous pression non soumis à la flamme - Partie 4: Fabrication

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This European Standard was approved by CEN on 23 May 2002.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This document (EN 13445-4:2002) has been prepared by Technical Committee CEN/TC 54 "Unfired pressure vessels", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2002, and conflicting national standards shall be withdrawn at the latest by November 2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this document.

In this standard the Annexes A and B are informative.

This European Standard consists of the following Parts:

Part 1: General.

Part 2: Materials.

Part 3: Design.

Part 4: Fabrication.

Part 5: Inspection and testing.

Part 6: Requirements for the design and fabrication of pressure vessels and pressure parts constructed from spheroidal graphite cast iron.

CR 13445-7, *Unfired pressure vessels - Part 7: Guidance on the use of conformity assessment procedures*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This document specifies requirements for the manufacture of unfired pressure vessels and their parts, made of steels, including their connections to non-pressure parts. It specifies requirements for material traceability, manufacturing tolerances, welding requirements, production tests, forming requirements, heat treatment, repairs and finishing operations.

This document does not give provisions for manufacturing requirements for vessels designed using Design by Analysis – Direct Route (DBA) of Annex B of EN 13445–3:2002.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 287-1:1992, *Approval testing of welders — Fusion welding — Part 1: Steels.*

EN 288-2:1992, *Specification and approval of welding procedures for metallic materials — Part 2: Welding procedure specification for arc welding.*

EN 288-3:1992, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for the arc welding of steels.*

EN 288-6:1994, *Specification and approval of welding procedures for metallic materials — Part 6: Approval related to previous experience.*

EN 288-7:1995, *Specification and approval of welding procedures for metallic materials — Part 7: Approval by a standard welding procedure for arc welding.*

EN 288-8:1995, *Specification and approval of welding procedures for metallic materials — Part 8: Approval by a pre-production welding test.*

EN 729-2:1994, *Quality requirements for welding — Fusion welding of metallic materials — Part 2: Comprehensive quality requirements.*

EN 729-3:1994, *Quality requirements for welding — Fusion welding of metallic materials — Part 3: Standard quality requirements.*

EN 875:1995, *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination.*

EN 876:1995, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints.*

EN 895:1995, *Destructive tests on welds in metallic materials — Transverse tensile test.*

EN 910:1996, *Destructive tests on welds in metallic materials — Bend tests.*

EN 1043:1995-1, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints.*

EN 1321:1996, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds.*

EN 1418:1997, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials.*

EN 10028-2:2002, *Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties.*

EN 10028-3:2002, *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized.*

EN 10028-4:2002, *Flat products made of steels for pressure purposes — Part 4: Nickel alloy steels with specified low temperature properties.*

EN 10216-1:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.*

EN 10216-2:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10216-3:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes.*

EN 10216-4:2002, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Non-alloy and alloy steel tubes with specified low temperature properties.*

EN 10217-1:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties.*

EN 10217-2:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10217-3:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes.*EN 10217-4:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 4: Electric welded non-alloy and alloy steel tubes with specified low temperature properties.*

EN 10217-5:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties.*

EN 10217-6:2002, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Submerged arc welded non-alloy and alloy steel tubes with specified low temperature properties.*

EN 10222-2:2002, *Steel forgings for pressure purposes — Part 2: Ferritic and martensitic steels with specified elevated temperature properties.*

EN 10222-3:2002, *Steel forgings for pressure purposes — Part 3: Nickel steels with specified low temperatures properties.*

EN 10222-4:2002, *Steel forgings for pressure purposes — Part 4: Weldable fine grain steels with high proof strength.*

EN 13445-1:2002, *Unfired pressure vessels — Part 1: General.*

EN 13445-2:2002, *Unfired pressure vessels — Part 2: Materials.*

EN 13445-3: 2002 *Unfired pressure vessels — Part 3: Design.*

EN 13445-5: 2002, *Unfired pressure vessels — Part 5: Inspection and testing.*

3 Requirements for manufacturing and subcontracting

3.1 Manufacturing

The general responsibilities of the pressure vessel manufacturer are stated in EN 13445-1:2002. Additionally to those requirements, the manufacturer shall ensure that:

a) the organisation for the control of manufacturing operations which includes special processes such as welding, forming and heat treatment shall be clearly defined by the manufacturer;

b) the manufacturing procedures such as welding, forming and heat treatment are adequate for the purpose and the pressure vessel meets the requirements of this standard. Where specific requirements are associated with materials these shall be taken into account, e.g. EAMs;

c) the manufacturing equipment is adequate for fabrication;

d) the staff is adequate for the assigned tasks;

NOTE As far as welding co-ordination is concerned, the qualifications, tasks and responsibilities can be defined by the manufacturer in accordance with EN 719 [1] in the job assignment.

e) the quality requirements for welding defined in EN 729-3:1994 are met as a minimum.

3.2 Subcontracting

The manufacturer may subcontract work, but shall ensure that the subcontractor carries out the work in accordance with the requirements of this European Standard. The manufacturer is responsible for the adequate definition of the subcontracted task and the need for any associated records.

On all occasions that the subcontractor work includes

a) welding;

b) forming including associated heat treatment;

c) post weld heat treatment;

d) non-destructive testing of welds (see EN 13445-5:2002).

The manufacturer shall obtain a subcontractor form (see Annex B).

Where welding operations are subcontracted, the manufacturer shall also either obtain copies of the welding procedure and welding operator qualification records or take other action to ensure that they comply with this standard.

In discharging his responsibility to ensure that the subcontractor carries out the work in accordance with this standard the manufacturer shall ensure that surveillance of the subcontracted work is performed.

Where a manufacturer is producing equipment that requires the intervention of a responsible authority, the manufacturer should inform the responsible authority of his intention to subcontract so that the responsible authority has the opportunity to take part in the subcontractor surveillance.

NOTE 1 See also prEN 764-3:1998, 2.11 [2] and CR 13445-7.

NOTE 2 When the manufacturer is producing equipment based on quality assurance, the controls a manufacturer applies over subcontractors should be described in his approved quality system.

4 Materials

4.1 General

Materials for pressure vessels and the grouping of materials for pressure vessels shall be in accordance with EN 13445-2:2002.

The grouping applies regardless of product form, i.e. plate, forging, piping.

4.2 Material traceability

4.2.1 General

The vessel manufacturer shall have and maintain an identification system for materials used in fabrication, so that all material subject to stress due to pressure and those welded thereto in the completed work can be traced to its origin. This includes the use of welding consumables.

4.2.2 Identification system

4.2.2.1 The vessel manufacturer's identification system shall assure that all materials to be used in the vessel have been subjected to and satisfactorily passed the following:

a) examination of material before fabrication for the purpose of detecting, as far as possible, imperfections which would affect the safety of the work;

b) check of material to determine that it has the required thickness;

c) check of the material to assure that the materials are permitted by this European Standard, fully traceable to the correct material certification and as specified in the design documentation;

d) check of the welding consumables to assure the correct markings and that correct conditions are maintained to prevent deterioration.

4.2.2.2 Material traceability to the original identification markings shall be by one or more of the following methods:

a) accurate transfer of the original identification markings to a location where the markings will be visible on the completed vessel;

b) identification by a coded marking traceable to the original required marking;

c) recording the identification markings using material lists or as built sketches which assure identification of each piece of material during fabrication and subsequent identification in the completed vessel;

d) the batch numbers of welding consumables shall be recorded.

4.2.3 Visibility

Materials which cannot be stamped or which will not be visible after the vessel is completed or for small multiple parts or non pressure parts the manufacturer may operate a documented system which ensures material traceability for all materials in the completed vessel.

4.2.4 Review of material certification and material identification

All material certification shall be reviewed upon receipt. The review shall cover the completeness and adequacy of the reports against the following:

a) mechanical and chemical properties required to be reported by the material specification;

b) assuring that the reported results meet the requirements of the specification;

c) all markings required by the material specification are satisfied and that there is traceability between the actual markings and those recorded on the material certification.

All materials certification shall be made readily available throughout manufacture.

4.2.5 Transfer of markings

In case the original identification markings are unavoidably cut out or the material is divided into two or more pieces the markings shall be accurately transferred by the manufacturer's nominated personnel prior to cutting.

The actual material marking shall be by methods which are not harmful to the material in subsequent use/operation.

The transfer of markings shall take place before partitioning of the product and after verification of the marks present with the corresponding certification.

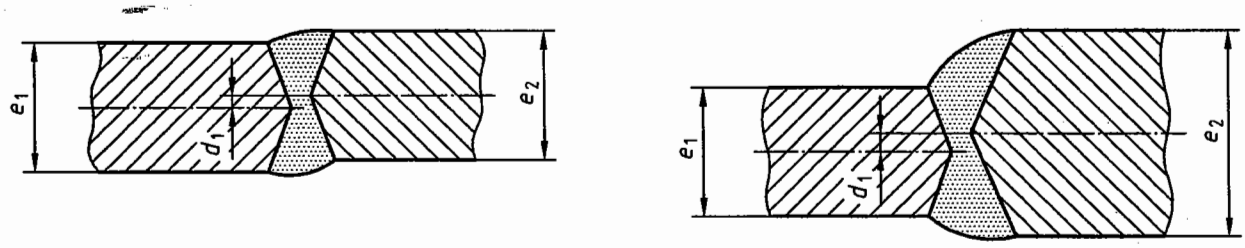
5 Manufacturing tolerances

5.1 Surface geometry of welds

The surface geometry of welded butt and fillet joints shall meet the requirements of EN 13445-5:2002 unless the drawing specifies more stringent requirements.

5.2 Middle line alignment

The misalignment tolerances of middle lines shall be as specified in Tables 5.2-1, 5.2-2, 5.2-3 and Figure 5.2-1.



a) Middle line alignment d_1 at equal thickness $e_1 = e_2$ **b) Middle line alignment d_1 at different thickness $e_1 \leq e_2$**

Figure 5.2-1 - Middle line alignment d_1

For longitudinal welds in cylinders, cones and rectangular/prismatic structures the middle lines of adjacent components (whether of equal or different thickness) shall be aligned within the tolerances specified in Table 5.2-1.

Table 5.2-1 — Offset of middle lines for longitudinal welds in cylinders, cones and rectangular/prismatic structures

Dimensions in millimetres

Thinner part thickness e_1	Maximum misalignment d_1
$e_1 \leq 2$	0,5
$2 < e_1 \leq 4$	$e_1/4$
$4 < e_1 \leq 10$	1
$10 < e_1 \leq 30$	$e_1/10$
$30 < e_1 \leq 60$	$e_1/30 + 2$
$60 < e_1$	4

For longitudinal welds in dished ends and welds in spherical components the middle lines of adjacent parts (whether of equal or different thickness) shall be aligned within the tolerances specified in Table 5.2-2.

Table 5.2-2 — Offset of middle lines for longitudinal welds in dished ends and in spherical components of adjacent parts

Dimensions in millimetres

Thinner part thickness e_1	Maximum misalignment d_1
$e_1 \leq 2$	0,5
$2 < e_1 \leq 4$	$e_1/4$
$4 < e_1 \leq 10$	1
$10 < e_1 \leq 30$	$e_1/10$
$30 < e_1 \leq 120$	$e_1/30 + 2$
$120 < e_1$	6

For circumferential welds the middle lines of adjacent parts (whether of equal or different thickness) shall be aligned within the tolerances specified in Table 5.2-3.

Table 5.2-3 — Offset of middle lines of circumferential welds of adjacent parts

Dimensions in millimetres

Thinner part thickness e_1	Maximum misalignment d_1
$e_1 \leq 30$	$e_1/10 + 1$
$30 < e_1 \leq 150$	$e_1/30 + 3$
$150 < e_1$	8

5.3 Surface alignment

5.3.1 Surface misalignment between parts

Where there is misalignment at the surface between parts of the same nominal thickness the transition across the weld shall be smooth and gradual with a slope of 1 in 4 over the width of the weld. If this taper cannot be accommodated within the weld width it is permissible to either:

a) grind the higher plate surface, where this will not reduce the joint thickness at any point below the nominal specified plate thickness minus the plate thickness tolerance;

b) build up the lower plate surface with added weld metal

5.3.2 Joining of parts of different thickness

Where different thickness are being joined a taper shall be produced in accordance with EN 13445-3:2002 by either:

a) taper the thicker plate in accordance with the design drawing and then applying the requirements above for the same nominal thickness parts; or

b) obtain the required slope across the width of the welds, or by a combination of weld build up on the lower surface with added weld metal and thereafter obtain the required slope across the weld width.

5.4 Tolerances for vessels subjected to internal pressure

5.4.1 External diameter

For cylindrical and spherical pressure vessels the mean external diameter derived from the circumference shall not deviate by more than 1,5 % from the specified external diameter.

For rectangular vessels and/or prismatic structures each external dimension shall not deviate by more than 1,5 % from the specified external dimension.

5.4.2 Out of roundness

Out of roundness (O) shall be calculated in accordance with the following equation (5.4-1):

$$O\,[\%] = \frac{2 \cdot (D_{max} - D_{min})}{D_{max} + D_{min}} \cdot 100 \qquad (5.4\text{-}1)$$

It shall not exceed the following values:

a) 1,5 % for the ratio of $e/D < 0{,}01$;

b) 1,0 % for the ratio of $e/D \geq 0{,}01$.

NOTE The determination of the out of roundness need not consider the elastic deformation due to the deadweight of the pressure vessel.

Irregularities in vessel profile (e.g. dents, buckling, flats on nozzle positions) shall be also within the tolerances in a) and b). A greater out of roundness may be acceptable provided they have been proven admissible by calculation or strain gauge measurements.

5.4.3 Deviation from the longitudinal axis

The deviation from the longitudinal axis over the length of the cylindrical portion of the pressure vessel shall not exceed 0,5 % of the length of the shell.

5.4.4 Irregularities in profile

a) Local irregularities in vessel profile

Irregularities in profile (e.g. dents, buckling, flats on nozzle positions) shall be smooth and the depth shall be checked by a 20° gauge and shall not exceed the following values:

1) 2 % of the gauge length; or

2) 2,5 % of the gauge length provided that the length of the irregularities does not exceed one quarter of the length (with a maximum of 1 m) of the shell part between two circumferential joints.

Greater irregularities require proof by calculation or strain gauge measurement that the stresses are permissible.

b) Peaking on longitudinal butt welds

When irregularity in the profile occurs at the welded joint and is associated with "flats" adjacent to the weld, the irregularity in profile or (peaking) shall not exceed the values given in Tables 5.4-1 and 5.4-2.

Measurement for peaking shall be made by means of a 20° profile gauge (or template), see Figure 5.4-1, or other types of gauge such as a bridge gauges or needle gauges.

For outwards peaking two readings shall be taken, P_1 and P_2 on each side of the joint, at any particular location, the maximum peaking is determent using equation (5.4-2)

$$P = 0{,}25 \cdot (P_1 + P_2) \qquad (5.4\text{-}2)$$

The inwards peaking P shall be measured.

The inside radius of the gauge shall be equal to the nominal outside radius of the vessel.